TEMPORAL FLOW VARIABILITY IN JOHOR RIVER BASED ON WAVELET ANALYSIS

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Ummi, Abah, Siblings, Nieces, Nephews and Fahmi.

You mean the world to me and I love each and every one of you.
I dedicate this to all of you.

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ABSTRACT

This study focuses on the variability of Johor River discharge using Fourier and Wavelet Analysis. Variability of river discharge refers to the characteristic of river discharge. The main focus in this study is to determine the changes of a river discharge with respect to time and period based on the data obtained. Understanding the temporal patterns of variability in discharge records is essential for the interpretation and explanation of changes to river geology. This study uses a univariate Johor River discharge data obtained from Rantau Panjang station which is taken for a period of 30 years consecutively. The data was obtained from the Department of Irrigation & Drainage Malaysia using a machine called "Automatic Water Level Recorder". Analysis was done based on the weekly average of the discharge data. The short term variability of Johor River discharge data is between 0.6 years to 2.5 years. However, for long term variability, the answer we obtained for wavelet analysis is considered statistically less reliable because the region falls in the Cone of Influence (COI).

ABSTRAK

Kajian ini memberi tumpuan kepada kebolehubahan saliran air Sungai Johor menggunakan analisis Fourier dan Wavelet. Kebolehubahan aliran air sungai merujuk kepada ciri-ciri aliran sungai. Fokus utama dalam kajian ini ialah untuk menentukan perubahan aliran sungai berkenaan dengan masa dan tempoh yang berdasarkan data yang diperolehi. Memahami corak kepelbagaian masa dalam melaksanakan rekod adalah penting untuk tafsiran dan penjelasan mengenai perubahan untuk geologi sungai. Kajian ini menggunakan data univariat Sungai Johor yang diperolehi dari Stesen Rantau Panjang yang diambil sepanjang tempoh 30 tahun berturut-turut. Data yang diperolehi dari Jabatan Pengairan & Saliran Malaysia menggunakan sebuah mesin yang dipanggil "Perakam aras air automatik". Analisis dibuat berdasarkan purata mingguan data saliran air. Perubahan tempoh pendek saliran air Sungai Johor adalah di antara 0.6 tahun hingga 2.5 tahun. Tetapi, bagi perubahan tempoh panjang, jawapan yang kami perolehi untuk analisis wavelet di anggap secara statistiknya kurang kebolehpercayaan kerana rantaunya jatuh di dalam Kon Pengaruh (COI).

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

River discharge is the amount of water carried in a river at any one time which is formed from an overland flows combined together. River discharge is defined as the volume of water flowing past a given point during a given period of time. It is measured in cubic meter per second (m^3/s) and its records are in a form of time series data. The discharge of a river is important because it provides a direct measure of water quantity and hence the availability of water for specific uses. Furthermore, it provides the basis for understanding river basin processes and is essential for interpreting and understanding water quality.

River and its characteristics are constantly changing. Even the amount of water in a river changes. Some changes are caused by humans. Some of the changes are to do with space or location along a river and these changes are spatial. Some of the changes are to do with time, especially the period of the year and these changes may be temporal. According to Kirkup *et al.* (2001), understanding the spatial and temporal patterns of variability in discharge records is essential for the interpretation and explanation of changes to river geology. Kirkup *et al.* (2001) also added that, if river managers can gain a solid appreciation of rainfall and discharge variability in both spatial and temporal terms, and the interaction of this with human influences, it is possible that effective strategies for river rehabilitation can be established.

There are two major water-related problems affecting Malaysia, i.e. excess water (floods) and water shortage (droughts). These problems disrupt the quality of life and economic growth in a country and can result in severe damage and loss of

properties. Occurrences of flood in across the Johor River have become more frequent with higher flow magnitude. As reported by New Straits Times (2013), in the tail-end of 2006, Johor was hit by one of the worst flooding in history with the water level hitting 289 mm. A second wave of flood came unexpectedly on the third week of January 2007, flooding eight districts of the state. Also, earlier in January 2013, an overnight downpour caused flash floods in several areas in the state. Therefore, it is important to understand the variability of river discharge in order to predict flood, in water resource allocation and also serves as an important basis for assessing the impacts of climate change as explained by Franco-Villoria (2012). Furthermore, Malaysia have agreed to supply a maximum of 13 m^3/s of water to Singapore, so our studies will be valuable as to predict if there is enough water to be provided to Singapore in the future.

Variability refers to the extent to which these data points differ from each other. Variability of river discharge however, refers to the characteristic of river discharge. So what we are focusing in this study is the changes of a river discharge with respect to time and period based on the data obtained.

In this study, the data that we are dealing with is a non-stationary data. Non-stationary data, as a rule, are unpredictable and cannot be modeled or forecasted. The results obtained by using non-stationary time series may be spurious in that they may indicate a relationship between two variables where one does not exist. One method to measure variability is using Wavelet Analysis since it allows non-stationarity of a data. In this study, the variability of Johor River is identified by means of Wavelet analysis and Fourier analysis.

1.2 Problem Statement

Fourier Transform is a very common technique for extracting spectrum content of the time-series data. The main idea of this method is to transform time series from the time domain into the frequency domain. Fourier method makes it possible to get better information of the strongest signal of the variables without

unnecessary noise. In order to have stronger confidence of the analysis of the discharge variability, Wavelet Analysis was proposed.

Wavelet Analysis is one of the tools for analyzing the variability of non-stationary time series data. Hydrology data are non-stationary by nature including river discharge and most methods for determining the variability of hydrology data either cannot cater for non-stationary data or need to take additional measure to ensure the stationarity of the data.

Wavelet Analysis captures the local behavior at different time. They also added that, by filtering the original series, to obtain sequences of results which relate to variations at different scales (frequencies). All the information contained in the original time series is also preserved in its Wavelet Analysis.

1.3 Objective of Study

The objectives of this study are as follows:

i) To determine the temporal variability of Johor River using Fourier analysis.
ii) To determine the temporal variability of Johor River using Wavelet analysis
iii) To compare the variability results between Fourier analysis and Wavelet analysis based on their visualization approach.

1.4 Scope of Study

This study focuses on the variability of Johor River discharge using Fourier and Wavelet Analysis. This study uses a univariate Johor River discharge data obtained from Rantau Panjang station which is taken for a period of 30 years consecutively, which is from January 1980 to December 2010. The data was obtained from the Department of Irrigation & Drainage Malaysia using a machine called “Automatic Water Level Recorder”. Analysis was done based on the weekly average of the discharge data.

1.5 Significance of Study

At the moment, there is no known analysis or studies have been done on the stream flow characteristic or flow variability of Johor River. Hence this study will contribute to the knowledge of characteristic of Johor River. The results of this study will be beneficial to the statistical and hydrological studies. Understanding the water level allows us to predict and prepare for the weather change and also, ensure there is enough water to be supplied to Singapore. Furthermore, we are able to explore another method of determining the variability of a river discharge besides using the common Time Series Analysis and Fourier Analysis.

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